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Sourcing in the Air Force: An Optimization Approach

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Sourcing in the Air Force:
An Optimization Approach

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by

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Abstract

The U.S. Department of Defense (DoD) annually procures billions of dollars worth of systems, supplies, and services in support of the national military strategy. Faced with budget cuts and other resource constraints, the DoD must monitor its procurement process to ensure a continuous flow of critical supplies and services. One aspect of current transformation in DoD is the use of a strategic sourcing approach for the procurement of installation-level services. Using the Air Force's strategic sourcing process as our context, we develop an optimization model for selecting a set of bids among multiple offerors' proposals for installation services. The selection achieves the most favorable objective based on balancing the confidence performance level in past performance of the offerors and the cost to the Air Force. The research findings based on a realistic scenario demonstrate improvements in both overall performance and cost than the current process.

Keywords: contract management, strategic sourcing, optimization, set covering problem

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Table of Contents

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I. Background

Today's government agencies are operating in an environment characterized by countless economic and political disruptions to their sources of supplies and services. In order to survive in this turbulent marketplace, these organizations must continually monitor both their competitive position and their internally controllable processes—especially the contract management process. The Department of Defense (DoD) is no exception. The DoD annually procures billions of dollars worth of systems, supplies, and services in support of the national military strategy. The DoD Fiscal Year 2008 procurement budget included $388 billion for defense-related supplies and services (Government Accountability Office, 2009). Faced with these fiscal battles of budget cuts and resource constraints, the DoD must monitor its procurement process to ensure a continuous flow of critical supplies and services. The DoD procurement process will continue to increase in importance as the DoD acquires mission-critical and complex supplies and services.

The DoD has been undergoing a transformation in terms of how it manages its procurement function—to include its people, processes, practices, and policies. The DoD's procurement function is currently transforming from a transaction-oriented perspective to a strategic-oriented enterprise. No longer viewed as a tactical, clerical, or administrative function, the procurement function is gaining enhanced status and importance as leading organizations—including the DoD—understand and realize procurement's importance in achieving organizational strategic objectives as well as procurement's impact on competitive advantage. Furthermore, organizations are including procurement objectives in the development of corporate strategy and have placed great emphasis on developing corporate procurement strategies. One aspect of this transformation is the use of a strategic sourcing approach for the procurement of installation-level services. The Air Force has taken the lead in adopting a strategic sourcing approach for the procurement of its major installation-level services.

Using the Air Force's strategic sourcing process as our context, this research discusses the development and application of an optimization model for evaluating and selecting an offeror's proposal in an optimal bidding, source-selection approach. The objective of the research is to show how a pricing optimization (PO) model can be successfully used in optimal bidding approaches, in which multiple offerors propose at multiple locations. Specifically, this research applies combinatorial optimization to find a set of bids that will achieve the most favorable objective. This objective is based on balancing the confidence level in past performance of the offerors and the cost to the Air Force. This research is an innovative application of operations research to DoD contract management.

The reminder of this report begins with an introduction to the strategic sourcing process, identifying the various contracting phases and discussing strategic sourcing contracts. We then discuss how the Air Force is adopting strategic sourcing in its Installation Acquisition Transformation initiative (IAT). A review of optimization concepts will then introduce the PO model and apply it to a simulated strategic sourcing, source-selection scenario. Analysis of results for these scenarios is presented. We conclude with an assessment on the potential use of PO-like models in future DoD strategic sourcing source selections.

II. Literature Review

In this exploratory research, we develop a set covering problem for the strategic sourcing initiative for contracting in Air Force. Thus, our literature review focuses on these two topics: strategic sourcing and contracting management, and the set covering problem from combinatorial optimization.

Procurement Transformation

The transformation of the purchasing and procurement function from a passive, administrative, and reactive process to a proactive, strategic, boundary-spanning function was predicted back in the early sixties' purchasing literature when Henderson (1975, p. 44) stated that the procurement function would gain increased importance in corporate management. As we begin the tenth year into this new millennium, the purchasing and procurement transformation continues to build up steam and reap benefits for leading-edge organizations. The procurement transformation reflects a new approach to purchasing and procurement that embraces the other supply chain management functions of materials management, logistics, and physical distribution—this new approach has been labeled "supply management" by many organizations and industries (Bhote, 1989).

This supply management focus requires organizations to adopt a strategic orientation to their procurement function and to look more at the total supply chain management process and its effect on their organization's competitive strategy. More specifically, the supply management focus involves linking the organization's procurement, or sourcing, strategy with its corporate competitive strategy. This requires supply managers to become active participants in developing their organization's strategic business plan—which now includes the integration of supply, marketing, finance, and conversion strategies (Burt, Dobler & Starling, 2003).

Supply management has been described as a new management concept that integrates the company's purchasing, engineering, and quality assurance functions with the supplier—with each function working together as one team early in the procurement process to further mutual goals (Bhote, 1989). Of course, the supply function has always existed in all organizations to ensure that all needs are met in terms of quality, quantity, delivery, cost, service, and continuity. However, the traditional view of supply focused more on the function's operational, or "trouble avoidance" contribution to organizational objectives. The new concept described focuses on supply management's strategic contributions to organizational objectives, such as the opportunistic or profit-maximizing aspects. In addition, this concept of strategic supply management differs from the traditional approach in the fact that the organization becomes integrated with selected suppliers, working as one team toward mutual goals. This concept also differs significantly from the traditional adversarial approach to supply management in which suppliers were kept at an arm’s-length distance from the organization. Other major developments in the transformation of purchasing to supply management include the breaking down of functional walls with the use of cross-functional teams, the development and management of supply chains and supply alliances, the use of electronic procurement systems, and the adoption of strategic sourcing approaches (Burt et al., 2003).

III. Strategic Sourcing

Strategic sourcing is probably the most significant aspect characterizing an organization's transformation to supply management. It is also this aspect of supply management which provides some of the most value-added benefits to the organization. Sourcing, one of the major steps in the procurement process, involves the identification and selection of the supplier whose costs, qualities, technologies, timeliness, dependability, and service best meet the organization's needs (Burt et al., 2003).

Strategic sourcing involves taking a strategic approach to the selection of suppliers—an approach that is more aligned with the organization's competitive strategy. Strategic sourcing reflects the integration of procurement or sourcing strategy with corporate strategy. The integration of procurement and corporate strategy is reflective of the transformation of purchasing to supply management.

One application of strategic sourcing is the use of a commodity sourcing strategy—the development and application of a carefully crafted strategy for the procurement of quality supplies and services at the lowest cost (Gabbard, 2004). The commodity sourcing strategy focuses on developing a specific sourcing strategy for a category or group of supplies or services. It should be noted that the term "commodity" should not be associated with traditional commodities such as copper, ore, cotton, or barley, nor should it be associated with non-complex supplies or services. The term "commodity" is used solely to refer to categories or groups of supplies or services. The success of commodity strategies is based on an organization's ability to maximize the cost-reduction advantages of the following: leveraging combined buying power for volume discounts, utilizing market experts to formulate a sourcing strategy, and finally, forming strong relationships with preferred suppliers (Reed, Bowman & Knipper, 2005).

Commodity sourcing strategies require a distinct strategy-planning process developed for that specific group of supplies or services. Lasseter's Balanced Sourcing Model reflects a generic commodity strategy-planning process involving the following seven activities (Lasseter, 1998): (1) Spend analysis, (2) Industry analysis, (3) Cost/performance analysis, (4) Supplier role analysis, (5) Business process reintegration, (6) Savings quantification, and (7) Implementation. These activities are discussed below:

Lasseter's commodity strategy-planning process provides an effective template for developing a commodity sourcing strategy for a specific group of supplies or services. The next section of this research report will discuss the application of strategic sourcing and commodity strategies in the commercial industry.

Strategic sourcing strategies have been successfully implemented by IBM (Carbone, 1999; Reed et al., 2005), Deere & Co. (Smock, 2001), Lucent Technologies, (Carbone, 2002), Cessna Aircraft Co. (Avery, 2003), and Hewlett-Packard (Carbone, 2004). Each of these world-class purchasing organizations has successfully implemented strategic sourcing and commodity procurement strategies and has reaped the benefits of transforming its purchasing function to a strategic, integrated supply-chain process. Based on these successes, many government agencies are now beginning to implement and adopt strategic purchasing best practices. The next section will discuss initiatives within the Department of Defense to implement strategic sourcing, and specifically, commodity strategies.

Set Covering Problem

Set covering problem (SCP) is a classic problem in operations research (e.g., Nemhauser & Wolsey, 1999, pp. 6-7). The SCP hypothesizes a finite set U and a family S of subsets of U is given. The goal is to find a minimum-cost subfamily of S, referred to as a "cover," $C \subset S$, such that the union of all the sets in C is U.

Assuming that each $s \in S$ incurs a fixed cost $c(s)$, the SCP can be formulated as follows:

$$\text{SCP: minimize } \sum_{s \in S} c(s) X_s \tag{1}$$

$$\text{subject to} \quad \sum_{s \in S \mid u \in s} X_s \geq 1, \ u \in U \tag{2}$$

$$X_s \in \{0,1\}, \forall s \in S \tag{3}$$

In this formulation, equation (1) minimizes the total cost of the cover, (2) ensures every element in the original set *U* is covered by at least one subset in the cover, and (3) describes that every subset either is in the cover or not.

Applications of SCPs abound. For example, a local government wants to establish locations of fire-stations so that all communities are covered with least number of fire-stations, which results in lowest fixed cost. This problem—whose objective function typically minimizes the number or cost of facilities required—is also known as the least-cost, maximal covering problem (Toregas, Swain, ReVelle & Bergman, 1971).

SCP has been extended to problems in which coverage time is used instead of distance. A survey of these problems can be found in Church and ReVelle (1974). There have been various modifications of this model—as reviewed extensively by Marianov and ReVelle (1995)—for emergency services. Drezner (1995) also offers an extensive survey of applications and methods of solution process facility location problems.

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IV. Air Force Initiatives and Processes for Contracting

Just as the commercial sector has experienced success in transforming its procurement processes, initiatives are now in place to improve public-sector purchasing and procurement processes (Husted & Reinecke, 2009). As discussed at the beginning of this paper, the DoD's procurement process is currently undergoing a transformation similar to the procurement transformation being experienced by the commercial sector. This transformation includes changes to the DoD's procurement processes, policies and practices. The strategic sourcing initiatives, and specifically the commodity strategy processes, successfully implemented by the commercial sector are now being considered and implemented by the DoD.

Many of these transformation initiatives were previously recommended by the GAO. Recent reports by the GAO have recommended that the strategic approach to procurement taken by the leading companies could serve as a general framework to guide the DoD's services contracting initiatives (GAO, 2002). In addition, the GAO also recommended that the DoD adopt the spend analysis best practices successfully implemented by the commercial sector, and use the resulting information as one of the key elements of implementing a strategic approach to procurement (GAO, 2003, June). The GAO also identified key elements of the strategic sourcing approach taken by leading companies, which are illustrated in Figure 1 (GAO, 2002). Finally, the GAO recommended that the DoD establish a management structure that adequately promotes a strategic orientation across the departments by setting performance goals—including savings goals—and ensuring accountability for achieving them (GAO, 2003, September).

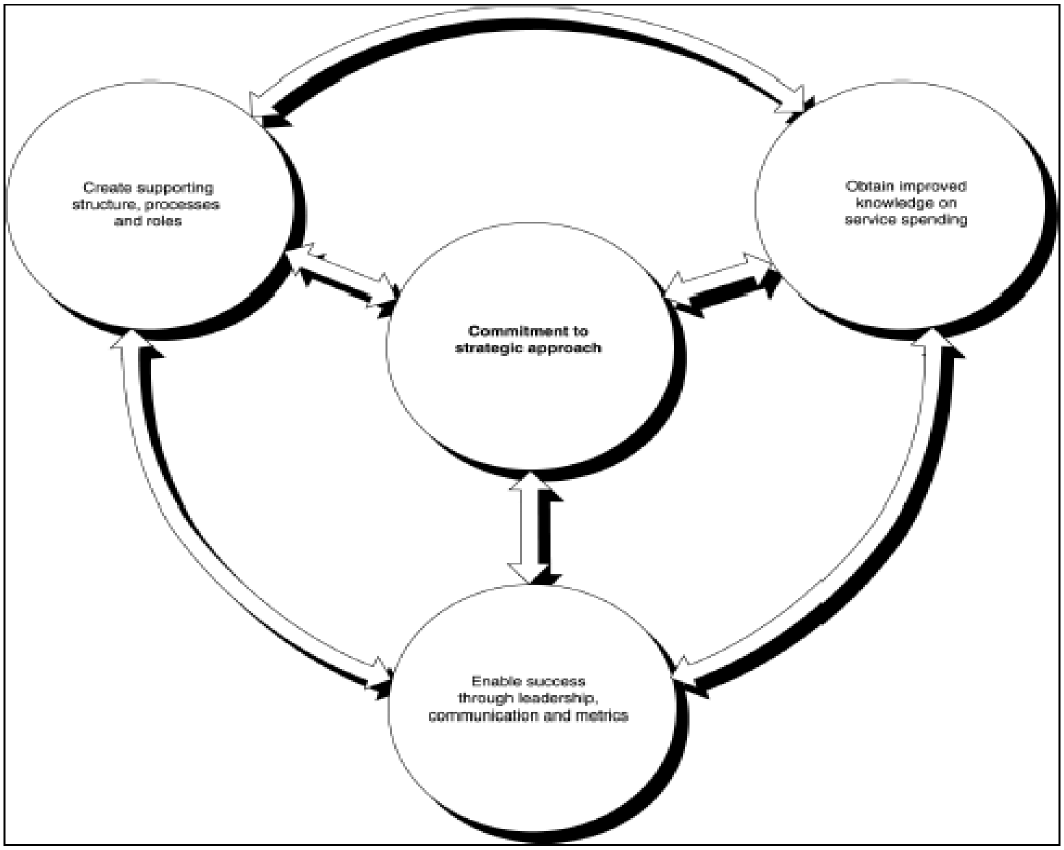

Figure 1. Key Elements of Strategic Approach Taken by Leading Companies
(GAO, 2002, January)

In response to these GAO reports, as well as other government audits, the Office of Management and Budget (OMB) issued a policy memorandum on May 20, 2005, to federal agencies requiring them to apply strategic sourcing principles to maximize the government's buying power. As stated in the OMB Policy Memo,

> Strategic sourcing is the collaborative and structured process of critically analyzing an organization's spending and using this information to make business decisions about acquiring commodities and services more effectively and efficiently. This process helps agencies optimize performance, minimize price, increase achievement of socio-economic acquisition goals, evaluate total life cycle management costs, improve vendor access to business opportunities, and otherwise increase the value of each dollar spent. (OMB, 2005)

The OMB memo also requires agencies to:

> report annually to the Office of Federal Procurement Policy (OFPP) regarding, at a minimum, reductions in the prices of goods and services, reductions in the cost of doing business, improvements in performance, and changes in achievement of socio-economic acquisition goals at the prime contract and, if possible, the subcontract level. (OMB, 2005)

One example of strategic sourcing in the federal government is the US Air Force Installation Acquisition Transformation (IAT) program. The IAT was approved by the Secretary of the Air Force in August 2007 to transform "contracting operations at all Air Force installations in the continental United States (CONUS) (SAF, 2009). The Air Force business case analysis identified the $15 billion annual spend as a prime target for strategic sourcing. Benefits from the IAT strategic sourcing include reduction of total cost of ownership, management of consumption, improved operating efficiency, and improved focus on socio-economic goals (IAT Industry Day Presentation, 2009).

The Air Force strategic sourcing model can be described using the basic contract management process—consisting of procurement planning, solicitation planning, solicitation, source selection, contract administration, and contract closeout (Rendon & Snider, 2008). The contract management process is discussed below.

Contract Management Process

1. **Procurement Planning**:

This is the process of identifying which organizational needs can be best met by procuring products or services outside the organization. This process involves determining whether to procure, how to procure, what to procure, how much to procure, and when to procure. Procurement planning activities include conducting stakeholder analysis, conducting outsourcing analysis, determining and identifying requirements and developing related documents, conducting market research, selecting the procurement method, and determining the contract and incentive type.

The majority of planning for strategic sourcing occurs in the procurement planning phase. In addition to the typical procurement planning activities discussed above, procurement planning for strategic sourcing would include a special emphasis on reviewing the current procurement strategy for the specific service, reviewing past and present business arrangements, conducting a total cost-of-ownership analysis, understanding industry trends and cost structure, and standardizing requirements.

2. Solicitation Planning:

This is the process of preparing the documents needed to support the solicitation. This process involves documenting the program requirements, competition environment, and identifying potential qualified sources. Solicitation planning activities include developing solicitation documents such as draft and formal RFPs (Request for Proposal) or IFBs (Invitation for Bid), developing contract terms and conditions, and developing proposal evaluation criteria.

3. Solicitation:

This is the process of obtaining information (bids or proposals) from sellers on how project needs can be met. Solicitation activities include advertising procurement opportunities, conducting industry and pre-proposal conferences, and amending solicitation documents as required.

4. Source Selection:

This is the process of receiving bids or proposals and applying evaluation criteria to select a service provider. Source-selection activities include evaluating proposals, negotiating contract terms and conditions, and awarding the contract. This is the key step in our research study. Our efforts are focused on making this step of the process more efficient.

5. Contract Administration:

This is the process of ensuring that each party's performance meets contractual requirements. Contract administration activities include conducting a post-award conference, monitoring and managing the contractor's performance, processing contractor requests for payments, and managing changes to the contract and related documents. This phase involves not only managing the contractor's performance, in terms of meeting the cost, schedule, technical, and quality requirements of the contract, but also monitoring the internal performance and management processes of the acquisition agency.

6. Contract Closeout:

This final phase is the process of verifying that all administrative matters are concluded on a contract that is otherwise physically complete. This involves completing and settling the contract, including resolving any open items. Contract closeout activities include verifying and documenting contract completion and compliance with requirements, making final payment, disposing of buyer-furnished property and equipment, documenting lessons learned and best practices, and collecting contractor past-performance information. If the service requirement continues to exist at the end of the contract period of performance, the procurement planning phase is conducted to begin the planning for the follow-on contract. Using the contract management process as a backdrop, we will now discuss some specific elements of strategic sourcing, such as type of contract and proposal evaluation strategy.

Contract Type

During the procurement planning phase of the contract management process, the type of contract to be used in the procurement is determined. The Air Force's strategic sourcing procurements typically involve a specific commodity of supplies or services (such as medical services, support equipment, or information technology) needed at multiple installations across the CONUS. Because of the level of uncertainty in regards to the delivery and quantity of the needed services at each installation, an Indefinite Delivery/Indefinite Quantity (ID/IQ) type contract is typically used. This would especially be the case for the strategic sourcing of installation services such as grounds maintenance or solid waste management (refuse and recycling) services. As described in the *Federal Acquisition Regulation* (*FAR*), an indefinite-quantity contract provides for an indefinite quantity, within stated limits, of supplies or services during a fixed period. The Government places task or delivery orders for individual requirements. Quantity limits may be stated as numbers of units or as dollar values. An ID/IQ contract is appropriate when the Government cannot predetermine, above a specified minimum, the precise quantities of supplies or services it will require during the contract period, and it is inadvisable for the Government to commit itself for more than a minimum quantity. The contracting officer should use an indefinite-quantity contract only when a recurring need is anticipated (FAR, 2009, Part 16.504).

In addition, according to the *FAR*, the contracting officer must give a preference to making multiple awards of indefinite-quantity contracts under a single solicitation for the same or similar supplies or services to two or more sources (FAR, 2009, Part 16.504(c)). Multiple-award contracts occur when multiple contracts are awarded from one solicitation. In the private sector, these are known as “bundled” awards, and usually involve some quantity discount. Multiple-award, task-order contracts (MATOCs) allow the government to procure supplies and services in a timelier manner using streamlined contracting procedures. Use of MATOCs leverages the advantage of price competition to obtain optimum prices. The basic MATOC typically has a broad scope of work, while the task orders issued under the basic contract typically will have a more specific and detailed work statement.

Proposal Evaluation Strategy

During the source-selection phase of the contract management process, the offeror’s submitted proposals are evaluated in accordance with the basis for evaluation. The basis for evaluation is determined during the procurement planning and solicitation planning phases and is documented in the solicitation.

The complexity of the source-selection process will depend on the procurement method selected. The source-selection process for a sealed bidding procurement will be formal, structured, and very mechanical—with the award being made to that responsible bidder whose bid, conforming to the invitation, will be most advantageous to the government, considering only price and the price-related factors (FAR, 2009, Part 14.408-1). In this type of source selection, there are no discussions or contract negotiations, and the types of contract use is typically firm-fixed-price, except that fixed-price contracts with economic price-adjustment clauses may be used if authorized.

Negotiated procurements, on the other hand, entail more of an extensive and complex source-selection approach, especially if a tradeoff process is used to arrive at "best value" decision. In these types of procurements, the source-selection process may include oral presentations, exchanges with offerors (to include clarifications and communications), as well as a requirement for submission and certification of cost or pricing data. The *FAR* describes "best value" as a continuum in which the relative importance of cost or price may vary for each specific procurement situation. In some contract source selections, in which the requirement is clearly definable and the risk of unsuccessful contract performance is minimal, cost or price may play a dominant role. In other source selections, in which the requirement is less definitive and more development work is required (resulting in greater performance risk), more technical or past performance considerations may play a dominant role (FAR, 2009, Part 15.101).

The government uses the lowest priced/technically acceptable source-selection process when best value is expected to result from selection of the technically acceptable proposal with the lowest evaluated price. In a lowest price/ technically acceptable source selection, the solicitation provides the evaluation factors and significant subfactors that establish the requirements of acceptability. In addition, tradeoffs are not permitted, and proposals are evaluated for acceptability, but are not ranked using the non-cost/price factors (FAR, 2009, Part 15.101-2). The contract is awarded to the proposal considered technically acceptable and also determined to be the lowest price.

The government uses the tradeoff process when it is believed that best value may be obtained from an "award to other than the lowest priced offeror or other than the highest technically rated offeror" (FAR, 2009, Part 15.101). The tradeoff process allows the government the flexibility to award to an offeror anywhere on the best value continuum between the lowest priced/technically acceptable offeror and the highest technically rated offeror. "This process permits tradeoffs among cost or price and non-cost factors and allows the Government to accept other than the lowest priced proposal" (FAR, 2009, Part 15.101). In this type of source selection, the solicitation shall clearly state all evaluation factors and significant subfactors that will affect contract award and their relative importance. In addition, the solicitation shall state whether all evaluation factors other than cost or price, when combined, are significantly more important than, approximately equal to, or significantly less important than cost or price (FAR, 2009, Part 15.101).

Strategic sourcing source selections will typically use a negotiated procurement method and a best value trade-off evaluation strategy. An often-used evaluation strategy for installation-level services is the performance price tradeoff (PPT) strategy.

The PPT process is a simplified best-value source-selection strategy that permits a tradeoff between price and performance in reaching the award decision. In a PPT source selection, the contract can be awarded to an offeror with a higher performance rating over a lower performance-rated offeror if the price differential is warranted and considered to be best value (USAF, 2008). Past performance information reveals how well the offeror performed work relevant to the type of effort and type of requirement described in the solicitation, and confirms whether the performance is current or recent (USAF, 2008).

A common PPT approach is to first evaluate the offerors' technical proposal on an acceptable/unacceptable basis. Next, the technically acceptable offerors are evaluated for price reasonableness and ranked by total evaluated price. Finally, the offeror's recent and relevant past performance is evaluated resulting in a performance confidence assessment rating. This evaluation process will result in an overall performance confidence assessment of substantial confidence, satisfactory confidence, limited confidence, no confidence, or unknown confidence. These ratings are described below.

Rating 1: *Substantial Confidence*: Based on the offeror's performance record, the government has a high expectation that the offeror will successfully perform the required effort.

Rating 2: *Satisfactory Confidence*: Based on the offeror's performance record, the government has an expectation that the offeror will successfully perform the required effort.

Rating 3: *Limited Confidence*: Based on the offeror's performance record, the government has a low expectation that the offeror will successfully perform the required effort.

Rating 4: *No Confidence*: Based on the offeror's performance record, the government has no expectation that the offeror will be able to successfully perform the required effort.

Rating 5: *Unknown Confidence*: No performance record is identifiable, or the offeror's performance record is so limited that no confidence assessment rating can be reasonably assigned.

If the lowest priced/technically acceptable offeror's past performance is rated as "substantial confidence" (the highest performance rating), that offer would be considered the best value to the government, and that offeror would be awarded the contract. If the lowest priced/technically acceptable offeror's past performance is not rated as "substantial confidence," then the next lowest price/technically acceptable offeror is assessed until an offeror is identified that is rated "substantial confidence" or until all offerors are evaluated. If stated in the solicitation, the government reserves the right to award a contract to a higher-priced offeror if the lower-priced offeror(s) has a lower performance confidence assessment. In the award to a higher-priced offeror with a better performance confidence assessment rating, the government must decide whether the past performance advantage of that offeror is worth the difference in price. This decision involves a best-value integrated assessment documenting the merits of the trade-offs between price and performance (USAF, 2008).

The proposal evaluation process discussed above is quite straightforward and noncomplex. However, in source selections for major strategic sourcing projects, the proposal evaluation process can significantly increase in complexity. This would especially be the case in the acquisition of services that are to be performed at multiple installations, using a best-value source-selection strategy such as performance price tradeoff (PPT), and awarding ID/IQ multiple-award, task order contracts (MATOC).   These strategic sourcing procurements present some unique challenges. One challenge is identifying the optimum procurement arrangement given the multiple installations, multiple offerors with varying performance ratings and different proposal prices for each installation, as well as proposals for combination of installations. In this complex strategic sourcing source selection, the use of mathematical modeling will help in identifying the optimum procurement arrangement. The next part of this paper will introduce the PO model and discuss the application of the model to a complex strategic sourcing source selection.

V. The Problem

The strategic sourcing for pricing of bids submitted by technically acceptable offerors on multiple installations can be modeled as an SCP, described by equations (1)-(3) earlier, conveniently adapted for our PO model, as shown later in this section.

In this case, the universal set consists of all the bids—single, as well as multiple contract types—as explained in the previous sections. For example, consider offerors A and B bidding for a certain service to be performed at installations 1, 2, and 3. Table 1 lists all the possible bids by these offerors on all the three installations. For example, Bid #1 is a bid offered by A on Installation 1 alone, whereas Bid #6 is a bid offered by A on Installation 1 and Installation 2, and Bid #7 offers the same service for the three installations clustered together. There are 14 such possible bids. However, in reality, all offerors may not bid on all possible bids due to their own preference or conditions imposed by the Air Force. One such stipulation may be maximum installations allowed to be included in a single bid, which is a parameter in our model. The principle underlying this strategy of bidding is that the more installations are included in a bid by the offeror, the more the discount in price due to, for example, economies of scale or geographic proximity. In other words, the sum of individual prices in Bids #1 and #2 for Installations 1 and 2 individually considered, respectively, is higher than the pricing in Bid #4 for Installations 1 and 2 included in a single bid. More generally, let b denote a bid for a group of installations I_b, and let p_b be its price. We assume the following "triangular" relationship holds:

If $I_b \cup I_{b'} = I_{b''}$, then, for any offeror bidding for I_b , $I_{b'}$, and $I_{b''}$, $p_b + p_{b'} > p_{b''}$.

Note that, if the above is not true, we may trivially eliminate bid b'' from the pool. In fact, the above may be generalized to mixed contractors and bids such that

$I_b \cup I_{b'} \supseteq I_{b''}$. That is, if offerors A, B and C bid on I_b, $I_{b'}$ and $I_{b''}$, respectively, we may eliminate the third bid if its price exceeds the sum of the other two.

Table 1. List of Possible Bids

Offeror	Bid #	Installation 1	Installation 2	Installation 3
A	1	x		
	2		x	
	3			x
	4	x	x	
	5		x	x
	6	x		x
	7	x	x	x
B	8	x		
	9		x	
	10			x
	11	x	x	
	12		x	x
	13	x		x
	14	x	x	x

The decision is which bids should be selected in order to achieve the preset strategy set by the authority. The strategy might be to choose those bids that enjoy the most confidence in performance level (CPL) without any consideration to the cost, or the bids that are least expensive with no consideration to CPL. However, common sense dictates that in most cases, the strategy will be a compromise between these two objectives. We account for this compromise by incorporating a weight as an input to our optimization model. The objective of the model is to achieve this preset strategy subject to the fundamental constraint that all installations receive the service.

We now state the underlying assumptions, based on our discussions with subject-matter experts. However, all these assumptions may be adjusted by individual program managers as they apply the model. For example, in the current scenario we assume the maximum number of installations an offeror can bid on simultaneously is five, but this number could be different for different offerors. We make the following assumptions solely for ease in developing the scenarios:

1. Each offeror bids on numerous bids, but the maximum number of installations, n, in a bid is fixed.

2. All offerors offer the same percentage of quantity discounts that are based on number of installations included in the bid.

3. All installations have the same preference in CPL of the offerors.

A. Notation

I	set of installations, for $i \in I$
C	set of offerors (contractors), for $c \in C$
B	set of bids, for $b \in B$
$B_i \subset B$	subset of bids which contain installation *i*
$I_b \subset I$	subset of installations in bid *b*
$c_b \in C$	offeror for bid *b*
p_b	price of bid *b* [$]
v_c	performance rating of offeror *c* [rating] (the lower the rating, the better the performance)
w	penalty weight of performance with respect to cost [$/performance rating]
h_i	penalty factor to reflect importance of having a good performance offeror for installation *i* [multiplicative factor]
x_b	binary decision variable: 1 if bid b is selected, and 0 otherwise

B. The Pricing Optimization Model: A Set Covering Problem

We model our PO problem for optimal offeror and bidding selection as the following SCP model:

$$\min_{x} \quad \sum_{b} (p_b + w v_{c_b} \sum_{i \in I_b} h_i) x_b \qquad (4)$$

$$\text{s.t.} \quad \sum_{b \in B_i} x_b \geq 1 \qquad \forall i \qquad (5)$$

$$x_b \in \{0,1\} \qquad \forall b \qquad (6)$$

The data provided to us did not contain combined bids by any offeror; that is, every bid available was exactly for one installation. For the purpose of this study, we have created combined bids by the following process:

Let:

$I_c \subset I$	subset of installations for which contractor *c* places individual bids
p_{ci}	price bid by offeror *c* on installation *i*, for $i \in I_c, c \in C$ [$]
n	maximum number of individual bids in a combined bid (pre-specified)
r_{ck}	discount rate offered by offeror *c* if awarded *k* installations simultaneously

<u>Process: Generate Cluster Bids</u>

For each offeror, $c \in C$ {

For each $k = 1, 2, ..., \min\{n, |I_c|\}$ {

- For $l = 1,2,...,\binom{|I_c|}{k}$ {

  Add a new bid identifier *b* (e.g., a bid counter index) to set *B*

- Generate the l^{th} (combined) bid *b* which has exactly *k* installations from I_c
- Update set B_i for installations in the just-generated bid
- Update the cost of the combined bid by using the discount rate:

  $$p_b = r_{ck} \sum_{i \in I_b} p_{ci}$$

}}} End process

C. Implementation

The names of the installations and offerors have been altered to maintain confidentiality. This specific scenario for implementing the model has 18 offerors and 13 installations. The cost of single bids is shown in Table 2.

Table 2. Single Bids

	IA1	IC1	IG1	IK1	IL1	IL2	IL3	IL4	IM1	IR1	IS1	IT1	IV1
OC1			$ 298,565		$1,309,276					$582,403		$495,784	
OP1	$723,485	$237,556	$ 286,125	$917,634	$1,425,608	$156,354				$592,445			
OD1	$650,125	$215,445	$ 245,369	$925,618	$1,350,874	$175,894	$ 408,996	$278,996		$585,226	$579,446		
OS1				$921,658		$225,789	$ 424,608	$292,115	$817,780	$601,298			
OA1	$627,569			$952,325			$ 375,000	$262,395		$587,497			
OA2			$ 398,565					$268,975		$592,668		$492,961	
OM1				$932,548			$ 364,860		$882,285	$592,235			
OS2													
OQ1			$ 456,000										
OM2		$199,064		$928,546					$837,601			$508,556	
OC2									$825,883				
OW1			$ 241,635					$250,976					
OS3	$925,684												$832,564
OI1		$208,565	$ 237,169	$930,584	$1,625,897	$250,325			$850,316	$658,988	$602,555		
OG1			$ 421,882	$948,687	$2,148,562					$985,236			
OK1	$823,186			$942,685	$1,526,512	$113,274	$ 384,509	$265,128	$905,112		$602,595		$548,126
OC3	$715,889												$ 19,762
OC4												$585,365	

Maximum bids allowed in a cluster are 5 (n) in the current scenario. Discounts given by offerors are given in Table 3. We also assign numerical values to CPL for utilizing the mathematical model solely for ease in developing the scenarios. These are given in Table 4.

Table 3. Discounts by Offerors

Number of Installations in Bids	Percentage Discount
For single bid	0
For 2	2
For 3	5
For 4	8
For 5	10

Table 4. Numerical Values for CPL

Substantial Confidence	1
Satisfactory Confidence	2
Unknown Confidence	3
Limited Confidence	4
No Confidence	5

Based on the given category of confidence in performance levels (such as substantially confident or not confident, for instance), and the numerical scale described in Table 4, each offeror was assigned a numerical value for its CPL. These are listed in Table 5. The smaller the value of CPL, the better the confidence in the performance level.

Table 5. Numerical Values of CPL for Offerors

Offeror	CPL
OA1	2
OM2	3
OI1	3
OP1	1
OC1	1
OK1	2
OM1	3
OW1	1
OS1	3
OC1	1
OD1	1
OA2	3
OC3	3

In order to understand the effects of changes in the strategies, we first evaluate total CPL (TCPL) and the corresponding cost based on the current selection process. Current selection processes (before applying the model) are based on two distinct principles. The first process of selection (Selection 1: Lowest Cost) chooses the least expensive single bid for an installation with no regard to CPL. This process parallels the sealed bidding procurement process or negotiated procurement process. The second process of selection (Selection 2: Best CPL and Lowest Cost), first chooses the offeror with the best CPL for that installation. If there is a tie, it is broken based on the lowest cost. This selection process parallels the PPT approach. Obviously, we do not reckon these as good strategies. For example, using the lowest-cost criterion, if one bid were just $1 higher than another, it would not be selected (even if the offeror were highly superior in CPL). In our example, the current selection process has 74 single bids for the 13 installations.

In order to implement the PO model, multiple bids were generated using the "Generate Cluster Bids" process. For 18 offerors and 13 installations (with a maximum of five installations in a combined bid), in addition to the given 74 single bids, there were 1,535 combined bids. Notice that this number increases rapidly due to bundling opportunities, making the selection process computationally complex and justifying the use of our PO model.

As was described in the formulation of the model, the objective function is to minimize cost in addition to incorporating the importance of CPL. Strategies for selection of bids depend on importance given by selectors to TCPL and, of course, the cost. Therefore, in order to vary the importance of CPL, a weight, α , was assigned for our test scenarios (as shown in Table 6). For example, given the other coefficients in our optimization model, setting α =100 favors a selection based predominantly on cost, whereas α =100,000,000 assigns the most importance to CPL.

Table 6. Scenarios and α

Scenario	α
Model-Scenario-1	100
Model-Scenario-2	10,000
Model-Scenario-3	1,000,000
Model-Scenario-4	100,000,000

VI. Results and Analysis

Results of the current selection processes are shown in Tables 7 and 8. The first selection process yields TCPL of 27, for a cost of $6,512,174. The second selection process yields a TCPL of 15, for a cost of $7,261,312. These results show that the least expensive strategic sourcing has a total CPL of 27—which translates to about an average TCPL of 2 per installation (satisfactory confidence in the performance level of the offerors). The second selection process, which prioritizes the offeror's CPL, yields an average TCPL of about 1.15 per installation (translating to slightly less than substantial confidence in performance), but this increase in confidence occurs at an extra cost of $749,138.

Table 7. Results from Current Selection Process 1 (Lowest Cost)

Installation	Offeror	CPL	Cost
IA1	OA1	2	$ 627,569
IC1	OM2	3	$ 199,064
IG1	OI1	3	$ 237,169
IK1	OP1	1	$ 917,634
IL1	OC1	1	$1,309,276
IL2	OK1	2	$ 113,274
IL3	OM1	3	$ 364,860
IL4	OW1	1	$ 250,976
IM1	OS1	3	$ 817,780
IR1	OC1	1	$ 582,403
IS1	OD1	1	$ 579,446
IT1	OA2	3	$ 492,961
IV1	OC3	3	$ 19,762
Total		27	$6,512,174

Table 8. Results from Current Selection Process 2 (Best CPL and Lowest Cost)

Installation	Offeror	CPL	Cost
IA1	OD1	1	$ 650,125
IC1	OD1	1	$ 215,445
IG1	OW1	1	$ 241,635
IK1	OP1	1	$ 917,634
IL1	OC1	1	$1,309,276
IL2	OP1	1	$ 156,354
IL3	OD1	1	$ 408,996
IL4	OW1	1	$ 250,976
IM1	OK1	2	$ 905,112
IR1	OC1	1	$ 582,403
IS1	OD1	1	$ 579,446
IT1	OC1	1	$ 495,784
IV1	OK1	2	$ 548,126
Total		15	$7,261,312

Results of the implementation of the PO model in Scenarios 1 through 4 are described in Table9. The TCPL ranges from 26 to 14, with the corresponding cost varying from $6,090,329 to $6,458,338.

Table 9. Results of the Model Scenarios

Scenario	Total CPL	Cost
Model-Scenario-1	26	$6,090,329
Model-Scenario-2	24	$6,108,861
Model-Scenario-3	14	$6,298,563
Model-Scenario-4	14	$6,458,338

For about the same average confidence in the performance level (satisfactory confidence), the solution from the model is cheaper than the current process solution by more than $500,000. On the other hand, for the best average TCPL (substantial confidence), the solution from the PO model is less expensive than that from the current process by almost $1,000,000. It should be noted that the highest cost solution from the PO model is cheaper, with better TCPL, than the cheapest solution from the current process. The most expensive pricing strategy obtained from the PO model is cheaper than the least expensive pricing strategy obtained from the current process. Figure 2 shows the comparison of these strategies.

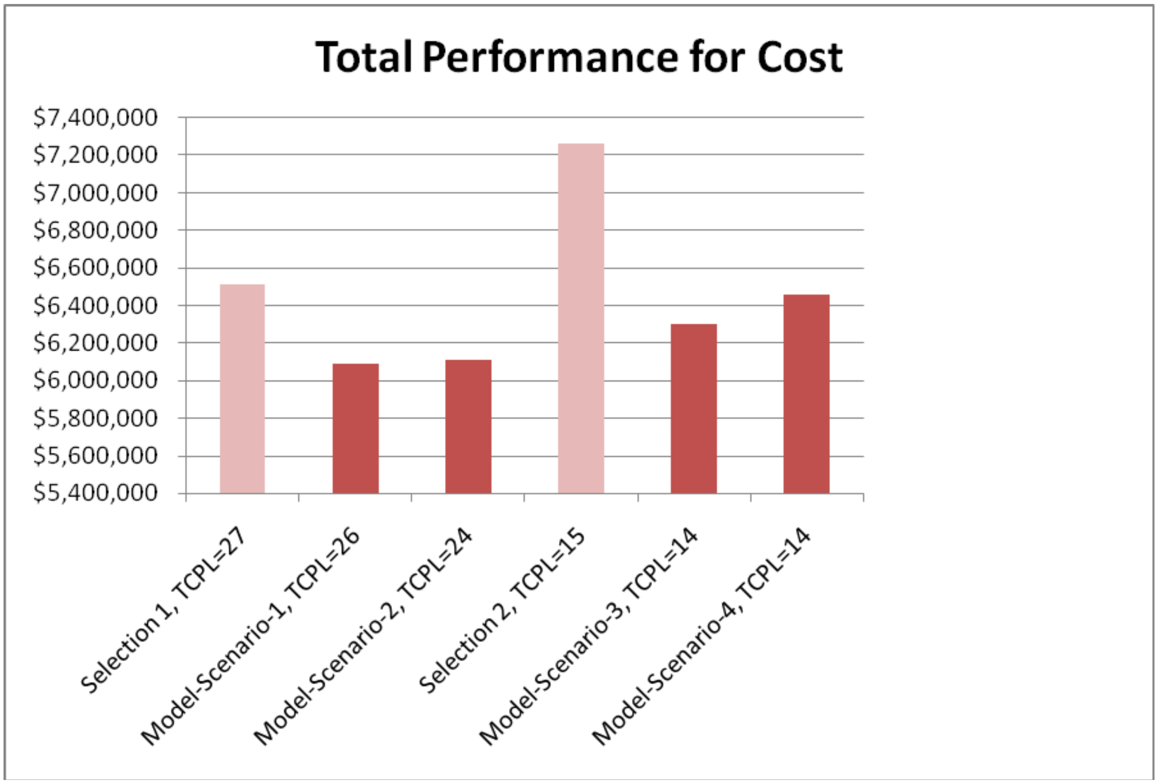

Figure 2. Comparison of Strategic Sourcing and Current Processes of Selection

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VII. Concluding Remarks

Strategic sourcing is a strategy for selecting suppliers of supplies or services. In this research, we adopted the Air Force's services sourcing strategy using an optimization approach. We discussed and verified that this approach was superior in many respects. One, it is an analytical approach that can be replicated and repeated for various services acquisitions. The solution obtained by this method is a strategy that identifies offerors with high past-performance levels and that costs significantly less than the current process. In addition, the researchers developed the mathematical pricing optimization model with parameters that can be changed based on different situations and that can use realistic data.

All the parameters and assumptions may be adjusted by individual program managers. For instance, as stated earlier in the current scenario maximum number of installations an offeror can bid on is 5, but it can be set to any single number or the model can be modified to incorporate different ceilings for different offerors. In the current scenario all percentage quantity discounts are the same for all offerors. However, realistically, these quantity discounts can be different for different offerors. For example, one offeror may offer a quantity discount of 10% for including 5 installations and the other may offer 12% discount for the same situation. The PO model was implemented in a scenario based on the data provided by the Air Force for 18 offerors and 13 installations. Out of 1609 bids, the model chose the bids based on importance given to TCPL, cost, and a combination of the two. The least-cost solution would save the Air Force approximately half a million dollars, with no change in TCPL. If the Air Force places more importance on TCPL, using our approach will save the Air Forceapproximately a million dollars.

This method can be expanded in scale to various regions in the Air Force, as well as to other DoD agencies such as the Navy and Army. The scope of the model in this research was limited to a single agency. Yet, it can be increased to multiple agencies in the future. Another natural extension of this research would be to develop a similar model for the strategic sourcing of supplies or specific commodities. At present, we are in the process of exploring these venues of research and possible implementations.

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Appendix. Acronyms

CONUS	Continental United States
CPL	Confidence in Performance Level
DoD	Department of Defense
FAR	Federal Acquisition Regulation
GAO	Government Accountability Office
IAT	Installation Acquisition Transformation
ID	Indefinite Delivery
IFB	Invitation for Bid
IQ	Indefinite Quantity
MATOC	Multiple Award Task Order Contract
OFPP	Office of Federal Procurement Policy
OMB	Office of Management and Budget
PO	Pricing Optimization
PPT	Performance Price Tradeoff
RFP	Request for Proposal
SCP	Set Covering Problem
TCPL	Total Confidence in Performance Level
WBS	Work Breakdown Structures

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